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ABSTRACT

Science is suggested as an excellent content area for teaching primary students the creative and critical thinking skills that can help them become better problem solvers. J. P. Guilford's Structure of Intellect model and Benjamin Bloom's Taxonomy of Educational Objectives serve as the basis for developing exercises which lead to improvement of creative and critical thinking abilities. Specifically, creative abilities are defined as the Divergent Production Operation in Guilford's model and as Synthesis and Application based on Knowledge in Bloom's Taxonomy; critical thinking skills are termed Evaluation in both classification systems. Nine exercises are provided, using birds, dinosaurs, insects, and plants to teach several skills in the areas of divergent production operation and evaluation. The area of divergent production covers semantic relations and systems, semantic implications, semantic systems, semantic transformations, and figural/visual implications. The critical thinking domain focuses on evaluation of figural/visual relations, figural/visual systems, symbolic transformations, and semantic implications. Worksheets, guidelines, and discussion questions are provided for teaching each skill. (JDD)

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WORKSHOP

CRITICAL THINKING ABILITIES THAT SUPPORT SCIENTIFIC SKILLS

A workshop to emphasize using higher levels of productive (critical/creative) thinking abilities to support and expand scientific skills. Participants will work through lessons based on critical/creative thinking theories, including Bloom and Guilford, using birds, dinosaurs, insects and plants as "vehicles."

Presented Sunday, February 7, 1988
CAG 26th Annual Conference
KEY TO THE FUTURE
Santa Clara, California

by Stella Pallas, Author, Educational Consultant
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Primary students' fascination with dinosaurs and their natural curiosity about insects, plants and birds make science an excellent content area for teaching creative and critical thinking skills leading to problem solving.

What is problem solving? When there is a need for new intellectual activity to go beyond information we already have, there is a problem to be solved. Although we do not know how we learn the skills for insightful problem solving it seems to be by drawing inferences; by trying to see relationships and patterns; by matching one fact with another fact which seems related.

Students need to be taught the skills for creative and critical thinking as well as to understand how these skills can help them to improve their intellectual powers leading them to become better problem solvers.

By applying Dr. Paul Torrance's four general areas of creative thinking: fluency, flexibility, originality and elaboration, students learn to reinterpret and reorganize information to build understanding of their own creative thinking.

Dr. Benjamin Bloom in his Taxonomy categorizes the creative skills and abilities as Synthesis and Application based on Knowledge.
Dr. J. P. Guilford in his Structure of Intellect-SOI-Model defines the abilities and skills as the Divergent Production Operation. Critical thinking abilities include the processes of appropriate judgment and decision making. Bloom and Guilford term this operation of the mind Evaluation. (Fig 1.)

Guilford, more specifically, has factored out the higher levels of creative and critical thinking skills leading to problem solving in his SOI Model. These higher levels include relations, systems, implications and transforming what one knows and experiences to produce new forms and patterns of information in creative and critical thinking. (Fig. 2.)

In-depth exercises which lead to improvement of creative and critical thinking abilities can be presented: (a) during a weekly 40-minute period set aside for teaching the skills, or (b) during the teaching of a content area every day, or two or three days each week. Both methods work. Teachers should select the most practical scheduling for their own classes.

When you've completed the sample exercises you will start thinking in your own creative way of other content areas where you will be able to apply the operations of the SOI Model. You already cover many of the operations.

Examples of exercises in Dr. Guilford's levels of Operations follow. They are only samples of some possibilities for teaching students creative and critical thinking skills. The point to be recognized is that the students, through discussion must be made aware of the fact that they are practicing learning to think.

CREATIVE THINKING: Divergent Production (Guilford); Synthesis and Application (Bloom)

DIVERGENT PRODUCTION-Semantic Relations and Systems. (Fig.3.) This exercise calls for practice in the skill of relating words to some other words. Tell the students there are no right or wrong

answers. Encourage students to think of as many words as possible... this must be done DELIBERATELY, each time, by the teacher. The examples given on the page will be familiar similes, however, we are introducing plant words to be related as similes (or analogies). Discuss students' reasons for relating words. This will help to clarify the skill in the minds of the students, so take this opportunity for discussion. Here is an opportunity to encourage some mental risk-taking. Read the directions with the students. When the page has been completed you will want to extend the exercise by having students use the similes in poetry.

DIVERGENT PRODUCTION-Semantic Implications (Fig. 4.) The purpose of this page is to observe thoughtful implications. Before giving students the page a motivation activity might be telling students they have been selected to put on the play for the Spring Program. They will be allowed to charge admission and the proceeds will be used to purchase playground equipment. Ask them what is the first thing they must do. (Make plans; a detailed list of what's to be done; materials to be ordered.) Start to put their responses on the board. (A student should be selected to record the information from the board.) Categorize with the students' help the things which need to be accomplished. Tell them they are generating ideas and recording them so nothing will be forgotten. Tell them there is only one rule--no idea is to be turned down, no matter how far out it may seem. Eventually they will look for the quality in ideas, but often those ideas which may have seemed silly at one moment might be quite practical for another reason. Continue this motivation until all ideas have been

exhausted and have then been categorized into a plan. Give the students the page. Read directions together. Provide paper on which students may write a number of statements or "captions" for each of the six cartoons. Here is an opportunity to have students do some "cooperative learning", perhaps some students would like to work with a friend (tell them writers of punch lines usually do work in pairs), or some students may wish to work alone. Let them make that choice. They should each generate at least 5 or 6 captions for each cartoon and then choose the 6 final captions which are of the highest quality. Tell them that writing takes discipline: writing many possible selections, freedom to be funny or sad, and even come up with a few surprises. Have students share their "captions". Comment only on cleverness, clarity, or uniqueness of each.

DIVERGENT PRODUCTION-Semantic Systems (Fig. 5.) After a study of dinosaurs, insects, birds or plants, students make up sentences (a thinking system) presenting an idea using only four beginning letters (in any order): W___ S ___ R___ L___. Only one other rule must be followed: NO OTHER WORDS MAY BE USED. Have students produce naming words, describing words, feeling words or words of how things seem to be. Do this by brainstorming. Work through several practice sentences with the class, pointing out they are practicing being flexible and fluent. Have them work in teams of three's to come up with at least five sentences each, after you read directions together. An extender to this exercise would be to <u>elaborate</u> (use that word with your students) by creating a story with one of the sentences as their theme.

DIVERGENT PRODUCTION-Semantic Transformations (Fig. 6.)

An exercise requiring thinking - transformations in Divergent Production can be hiding words in a sentence. Give students the page. Tell them if the word is already hidden in the sentence they are asked to produce a particular answer by finding the hidden word. By inventing the sentences themselves they must reach into their memory stores to find alternative, quality solutions to the problem. It is important that students know they are practicing the skill of transforming information. (Fig.7.)

DIVERGENT PRODUCTION-Figural/Visual Implications (Fig. 8.)

Projecting outcomes from ideas IMPLIED is a higher level of thinking. In this exercise students reach into their memory stores to generate information about a science lesson on which they are working. Do a practice exercise with the students before giving them the page. Put a half circle, at the left, on the board; next to it place a slanted right angle; just below and to the right of the angle draw another half circle. Give students paper to make lines like the ones you've drawn. Tell them to transform those lines into a "creation" of their own about the science lesson by adding any lines or embellishments they wish. After about five minutes let the students share the "ideas" they drew. Comment only on the unique use of the few lines they were given. Encourage individual differences. (Do not choose "best" or "worst" ideas.) Talk about how a more complete or detailed drawing expresses some ideas more clearly. Do not make the activity a contest.

Distribute the page to the students. Let the students work on the page after you have gone over the directions with them. When they have finished the page ask questions like: Did you have trouble with the page? Did you wait till you finished all five drawings to give them names or did you create a name after you had finished each drawing? Tell them we all work in our own individual ways. Ask which part they enjoyed most -- creating the drawing or naming it? Tell them we can learn to do both with practice and to feel comfortable while doing them. Ask if they were able to "lock up" any criticism while they were doing the exercise? Did not judging help them in creating ideas?

CRITICAL THINKING: Evaluation (Guilford and Bloom)

A requirement of critical thinking is to EVALUATE and re-EVALUATE information we have and then to make a decision or judgment requiring complex thinking.

EVALUATION-Figural/Visual Relations (Fig. 9.) This exercise is one in evaluating relationships to find similarities and differences when comparing (a) to (b), (a) to (c), etc., and eventually to find the ones that do not belong.

EVALUATION-Figural/Visual Systems (Fig.10.) Read the directions together. The rule is that "all figures get larger." The student EVALUATES the SYSTEM in each row to make a decision based on the rules or criteria established.

EVALUATION-Symbolic Transformations (Fig.11.) The exercise requires the student to look at the name of a bird which is in the box, EVALUATE the four words to its right, and then to decide which

of the four words are TRANSFORMATIONS of the given word. When students have completed the page ask questions like: What did you have to do to figure out the words? Did you find every word, or did you miss some? Why was it possible to miss some words? (Haste; didn't look carefully; didn't do mental transformation.) The skill takes time--share this thought--but it can be learned with practice. Ask if anyone became frustrated or unhappy while doing the words? How did that person deal with this emotion? Could they go to another word..or work from another direction? The EXTENDER at the bottom of the page will give students further practice in skills of researching, evaluating and presenting information.

EVALUATION-Semantic Implications (Fig.12.) We are often led astray by facts which have no bearing on a problem or a decision. In this exercise students must think critically by seeing IMPLICATIONS and by EVALUATING clues and non-clues. Read directions together. Tell students that one way of looking at a problem is to write down the things you know about it and then by eliminating or adding ideas as you get them. Have students work together on this one. When they have finished and you have discussed how they worked out their solutions explain that if we can think of possibilities when solving problems or go beyond the obvious, we can use the implications of our decisions instead of jumping to conclusions.

These exercises are only examples of some possibilities for teaching students creative and critical thinking skills. It is suggested for balance that exercises in the higher thinking levels of the Operations of Cognition, Memory and Convergent Production should be included in a program with Divergent Production and Evaluation.

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Fig.1.

INTEGRATING BLOOM and GUILFORD

BLOOM'S LEVELS	GUILFORD'S OPERATIONS
COMPREHENSION	COGNITION
Taking in, understanding information visual, auditory, kinesthetic	
KNOWLEDGE	MEMORY
Remembering what has been learned, observed, etc.	
ANALYSIS and APPLICATION	CONVERGENT PRODUCTION
Using information to determine the correct answer (Focused Search)	
KNOWLEDGE, SYNTHESIS and APPLICATION	DIVERGENT PRODUCTION
Using knowledge to create new ideas (Broad Search)	
EVALUATION	EVALUATION
Judging, making decisions based on evidence, values. (Comparing)	

GUILFORD'S OTHER SIDES

WAYS WE RECEIVE INFORMATION

FIGURAL/VISUAL
Through concrete objects/pictures

AUDITORY
Through sounds

SYMBOLIC
Through any symbol having MEANING to us (Numerals, Letters, Charts, Musical Notes, Diagrams....)

SEMANTIC
Through THOUGHTS and IDEAS, meaningful WORDS

BEHAVIORAL
Through actions and reactions of others

WAYS WE ORGANIZE INFORMATION TO USE IT

UNITS-ONE of anything (1 word, 1 numeral, 1 idea)

CLASSES-Grouping LIKE THINGS together (objects, words, ideas, attributes)

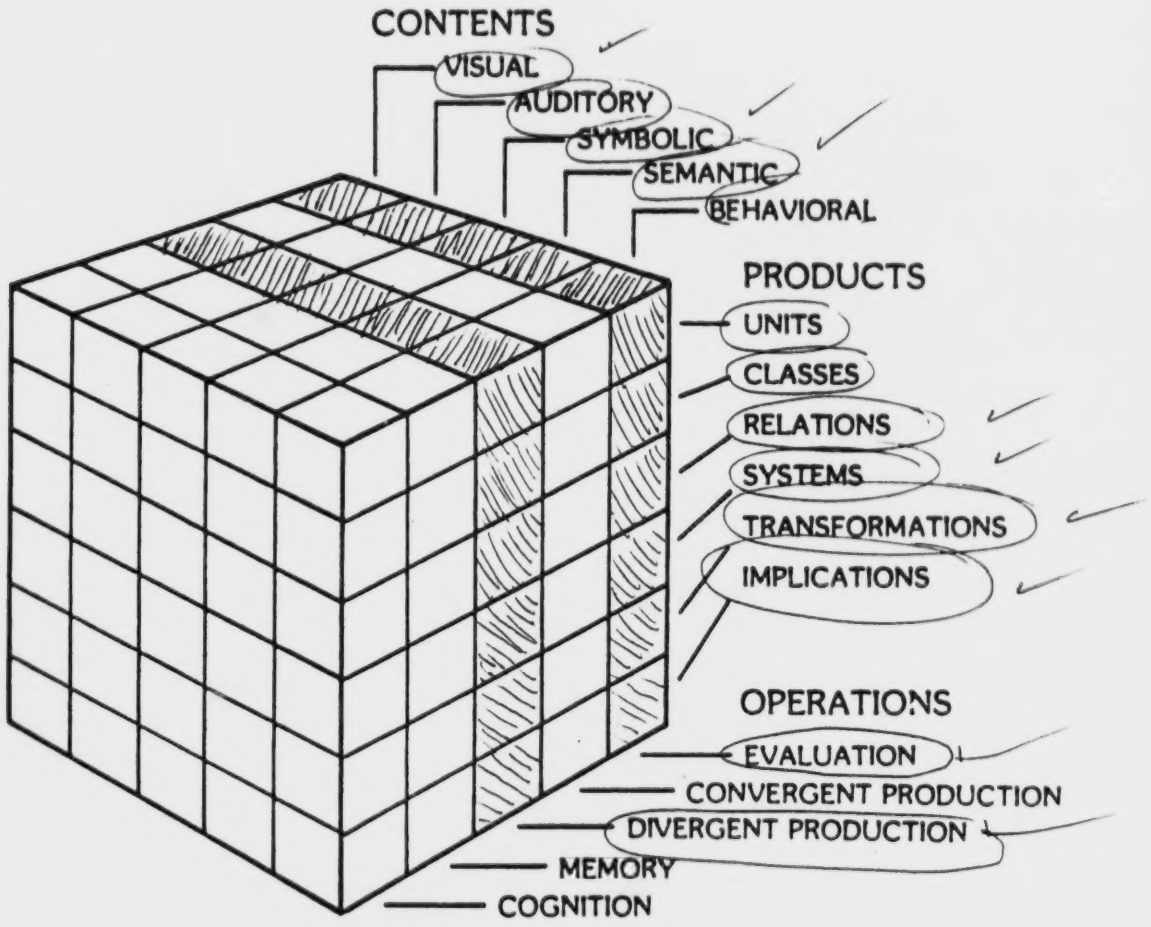
RELATIONS-Comparing things or ideas to see relationships

SYSTEMS-Regulated, orderly SEQUENCING of things or ideas.

TRANSFORMATIONS-Changing, reorganizing a given thing or idea into another thing or idea

IMPLICATIONS-Foresight, planning inferences

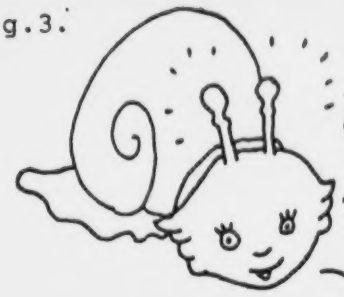
Fig.2. STRUCTURE-OF-INTELLECT MODEL



CODES FOR THE CATEGORIES

Operations		Contents		Products	
C	cognition	V	visual	U	units
M	memory	A	auditory	C	classes
D	divergent production	S	symbolic	R	relations
N	convergent production	M	semantic	S	systems
E	evaluation	B	behavioral	T	transformations
				I	implications

Fig.3.



D

Here's another GAME TO MAKE YOU A MORE FLEXIBLE THINKER. You can connect or relate all sorts of things in the world. If you are a FLEXIBLE THINKER you can see NEW or even STRANGE RELATIONSHIPS. Let me show you what I mean...

Take the words BUSY, LIGHT and GENTLE. I can relate them to the words BEAVER, FEATHER and LAMB. This is how I did the relating...

GENTLE as a LAMB

BUSY as a BEAVER

LIGHT as a FEATHER

These are called "SIMILES." (SIM-uh-leez)

NOW, you try some. Take a word from LIST A and relate it to any word from LIST B. THINK about WHY you put them together!

Take another word from LIST A and relate it to another word in LIST B. Use up all the words in both lists in this same way. (P.S. THERE ARE NO RIGHT OR WRONG ANSWERS.)

LIST A		LIST B	
• silent	• happy	• wild flower	• horsetail
• crunchy	• swift	• mushroom	• lichen

WRITE YOUR SIMILES ON THE LINES BELOW.

_____

_____

_____

_____

_____

Now, it is YOUR TURN TO CREATE YOUR OWN, NEW, STRANGE SIMILES.

• Get another piece of paper. Use any words you choose. Start out by making a list of words that tell how things FEEL or SEEM. Then, make a list of words that NAME THINGS. Connect the words in BOTH LISTS (as you did above) to make SIMILES.

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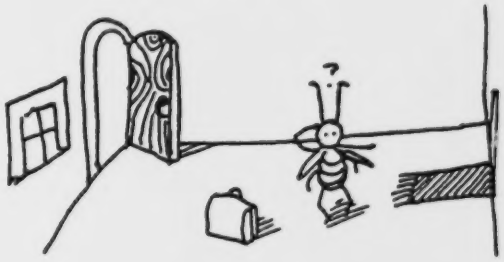
Fig.4.

Here's your chance to see thoughtful IMPLICATIONS (im-pli-KAY-shunz). Look at the cartoons below. What story do they SUGGEST to you? Write CAPTIONS (CAP-shunz) under each picture to tell a complete story. Your story should have: an INTERESTING BEGINNING -- a MIDDLE THAT IS SUSPENSEFUL -- and an ENDING THAT GIVES A MORAL OR LESSON.

Write your story on the lines under the pictures. Give your story a TITLE.

_____

TITLE

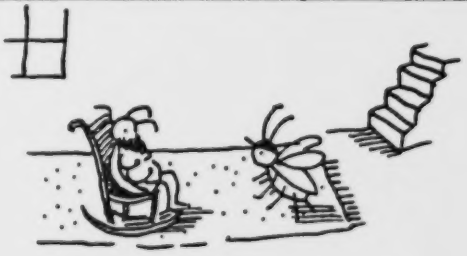


1. _____

_____

2. _____

_____

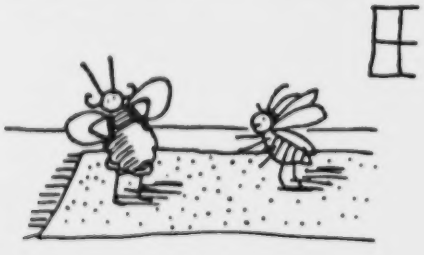


3. _____

_____

4. _____

_____



5. _____

_____

6. _____

_____

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Fig.5.

Here's your chance to become a SYSTEM BUILDER. How many sentences can you GENERATE about INSECTS using only 4 words ... the words must start with these letters -- and in this order! TRY IT!

(A) t g r n

Now - try these letters -- in this order -- to write sentences about insects!

(B) w s f c

Which letters were easier to use in sentences? Why do you suppose this was true? Did practice have something to do with making it easier? THINK ABOUT IT!

Set up a System builder for a friend with your own letters. See how many sentences your friend can generate about insects.

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Fig.6.

D

Here's a hidden word PUZZLE -- but you will be the one who CREATES it. Take the bird SWALLOW and hide it in a sentence -- I did one for you!

MisS WALL OWns that house.

NOW

You try some! Use the bird names on page 16 to write sentences with hidden birds!

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THINK about putting the following birds into as many DIFFERENT CLASSES as you can. Do the NAMES of the birds have anything IN COMMON? In what ways are they SIMILAR? Let your mind be FLEXIBLE.

Sparrow	Gannet	Starling	Titmouse
Oriole	Grebe	Thrush	Sandpiper
Junco	Pelican	Veery	Tern
Finch	Swallow	Raven	Gull
Road Runner	Wren	Crow	Goose
Loon	Thrasher	Chickadee	Duck
Penguin	Hummingbird	Kingfisher	Wood Pecker
Lark	Dove	Cuckoo	Pigeon
Plover	Crane	Pheasant	Quail
Grouse	Vulture	Hawk	Turkey
Eagle	Mallard	Teal	Shoveler
Warbler	Cardinal		

CLUES: How do they start, end, ... etc.

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Fig.7.

ALEX OSBORNE'S

CHECKLIST TO INDUCE TRANSFORMATIONS

ADAPT:	WHAT ELSE? Can I borrow from another source?
MODIFY/ SUBSTITUTE:	WHAT ELSE? WHERE ELSE? WHAT INSTEAD?
MAGNIFY:	ADD - MULTIPLY - EXTEND -
MINIFY:	Would it work better if smaller? SUBTRACT? DIVIDE? LEAVE OUT?
REARRANGE:	Furniture - Schedule
REVERSE:	TURN inside out Turn UPSIDE DOWN
COMBINE:	Eyeglasses became BIFOCALS thanks to BEN FRANKLIN -- and now we have TRIFOCALS

Fig.8.

D

Here's a chance to use your IMAGINATION. Now that you've <u>seen</u> quite a few birds, what kind of birds have you <u>never</u> seen? Construct 5 different IMAGINARY birds. Start with the letters in the boxes. Use as many more lines as you want to use!

r

Name:

Name:

Name:

Name:

Name:

Give each bird an UNUSUAL or CLEVER name!

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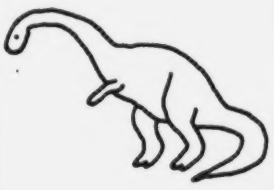
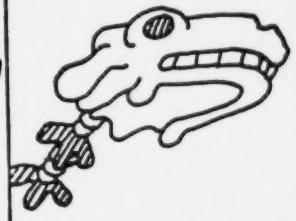
Fig.9.

E

How well do you find clues? Color the **TWO** that are **ALIKE** in each group?

	A	B	C	D
1				
2				
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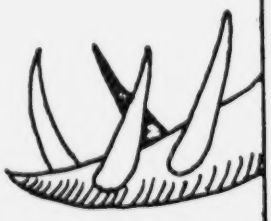
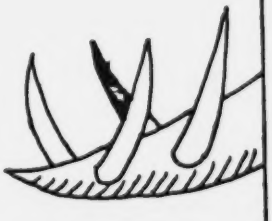
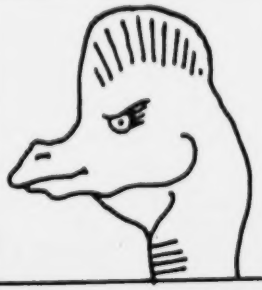
4				
5				

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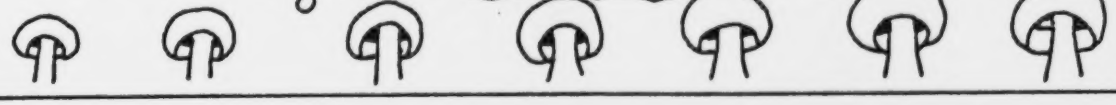
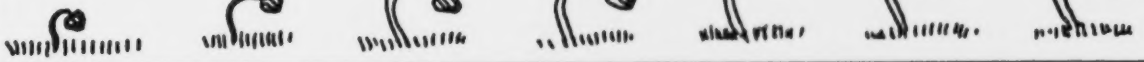
Fig:10.

SEE HOW WELL YOU CAN FOLLOW RULES!
EVALUATE each row using the RULE:
"ALL FIGURES GET LARGER." If the row follows that RULE, put an X in the circle at the start of that row!

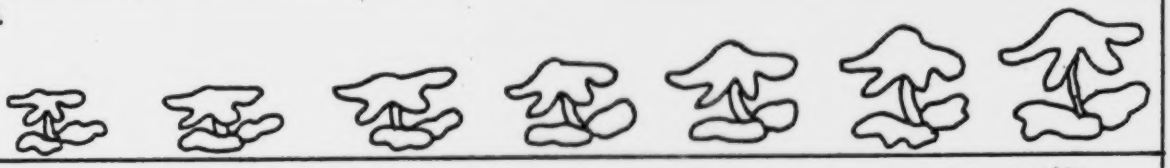
A.



B.



C.



D.

E.

F.

G.

H.

I.

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Fig.11.

NOW

I've TRANSFORMED some words ... made new ones. FIND a word (or words) that has the very SAME LETTERS as the word in the BOX. Try this one for practice: CLUE: Evaluate each word)

MASTER a. terms b. stream c. matters d. tamers

(Did you choose b and d? That's right!)

Look at the names of the birds in the boxes. Find one or more words in the line that has the very same letters. Circle the word or words.

1. OWL	(a) wool	(b) loon	(c) tow	(d) low
2. SWALLOW	(a) slowly	(b) allows	(c) wallows	(d) lowers
3. TEAL	(a) tale	(b) late	(c) tall	(d) alter
4. SNIPE	(a) price	(b) pines	(c) spine	(d) primes
5. GROUSE	(a) surge	(b) rouges	(c) course	(d) scourge
6. CRANE	(a) range	(b) caner	(c) cranks	(d) cream
7. CARDINAL	(a) Clarinda	(b) darling	(c) gridiron	(d) calendar
8. WARBLER	(a) crawler	(b) rambler	(c) reward	(d) brawler

EXTENDER

Look up the 8 birds in the encyclopedia. Find out the following 2 things about each of them.

1. What is their habitat?
2. What is their favorite food?

Write the information on the back of this paper.

Find out 2 more things about each bird. Share your research with a friend or your class.

EVALUATION
Symbolic Transformations

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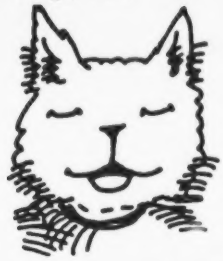
- Fig.12.

E



Three birds are visiting my backyard: A Meadowlark, an Oriole and a Mockingbird. One of the birds bathed in the bird bath; another one ate a worm; and the other one ate bird seed from the feeder.

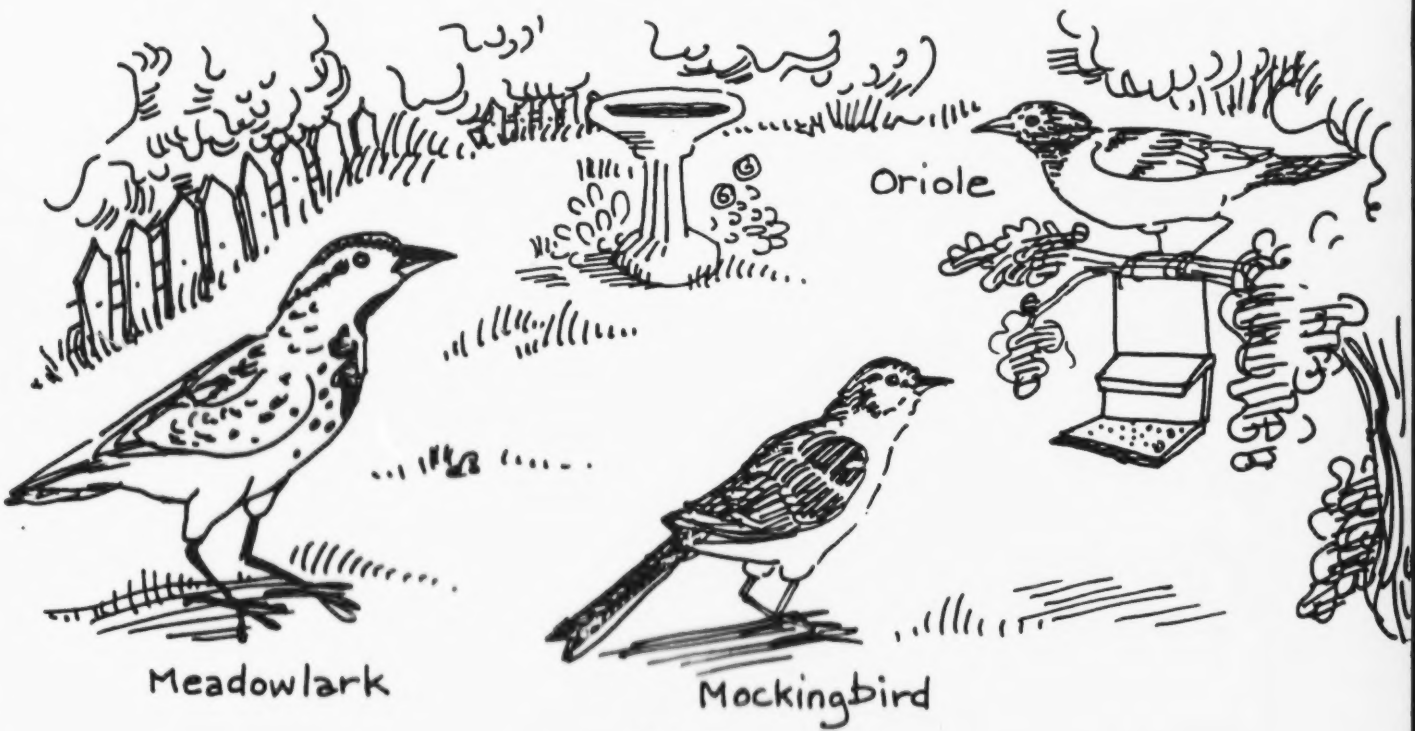
MATCH the birds with what they did!

CLUES:

1. A small flock of birds arrived. It was one of them that ate the bird seed.
2. The Oriole has orange feathers.
3. The Oriole did not bathe in the bird bath; the Oriole did not eat bird seed.
4. The Mockingbird came with a large flock.
5. The bird that ate bird seed likes to sit on the fence and sing.

Put your answers on the lines:

1. _____ Ate the worm
2. _____ Bathed in the bird bath
3. _____ Ate some bird seed



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